CSS Long Term Control Plan
Update Alternatives

Alternatives Evaluation: CSO Disinfection

City of Alexandria, VA
Department of Transportation and Environmental Services

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Attachments

Attachment A: Disinfection Alternative Cost Estimates

Executive Summary

Disinfection of combined sewer overflow is a common practice in the United States, with facilities installed in Detroit and Boston, among others. In most cases it is not a standalone control strategy, but used in conjunction with other CSO control strategies. Various physical and chemical disinfection technologies are considered, however, disinfection via sodium hypochlorite (NaOCl) serves as the basis for this evaluation. Sodium bisulfite is used for dechlorination.

When compared to the other alternatives, disinfection has some advantages in terms of footprint and cost; however, has many disadvantages including:

- Insufficient space to site the facilities for CSO 003/004;
- No volume reduction of the CSOs;
- No opportunity for nutrient and sediment credits;
- Only disinfects the bacteria load with no reduction in other pollutants;
- Requires delivery and storage of large quantities of strong oxidation and reduction chemicals in the urban setting of the City;
- Infrequent operation of mechanical equipment may lead to reliability challenges; and
- Deterioration of the stored sodium hypochlorite overtime due to infrequent operation.

Costs for the various sized disinfection facilities are presented in Table ES-1.

Table ES-1
Disinfection Cost Estimate Summary

Alternative	Construction Cost	Project Costs	Land Costs	Wet Weather Improvements	Total Capital Cost
D002-A	$8.3	$2.9	$1.7	$0.0	$12.9
D002-B	$29.8	$10.4	$4.2	$0.0	$44.4
D003/4-A	$6.1	$2.1	$2.3	$37.7	$48.2
D003/4-B	$29.4	$10.3	$7.1	$37.7	$84.5

It is recommended Alternative D002-A and D003/4-A be moved forward for scoring and ranking relative to the other alternatives.

The disadvantages above are further exacerbated for Alternatives D002-B and D003/4-B, as such it is recommended D002-B and D003/4-B be eliminated from further consideration.

Section 1 Alternative Description

1.1 Overview

The Waste Load Allocations (WLAs) assigned by the Hunting Creek TMDL to meet the City's Water Quality Standards (WQS) requires an 80% reduction in bacteria load for CSO-002, and 99% reduction for CSO-003 and 004. This evaluation provides an assessment of different disinfection technologies as alternatives to control discharge of pathogenic microorganisms from the CSOs and address the bacteria load reduction requirements to meet the City's WQS.

Disinfection of combined sewer overflow is included as part of many CSO treatment facilities, including those in Southeast Michigan, Detroit, MI; Boston, Massachusetts; Rochester, New York; and Syracuse, New York. In most cases it is not a standalone control strategy, but used in conjunction with other CSO control strategies. Various physical and chemical disinfection technologies are available for CSO facilities.

Disinfection of CSOs is more difficult to design and operate than the corresponding process in wastewater treatment plants due to the complex characteristics of CSOs. The flowrates of CSOs are highly variable which makes it difficult to regulate the addition of disinfectant. The concentration of suspended solids is high and the temperature and bacterial composition varies widely.

It is common to conduct pilot studies to characterize the range of conditions that exist for a particular area and the design criteria to be considered. Experience has shown that the long contact time required for conventional wastewater treatment is not appropriate for the treatment of CSOs; however, disinfection of CSOs to the levels typically required can be achieved by providing an increased disinfection dosage and intense mixing to ensure disinfectant contact with the maximum number of microorganisms.

1.2 Disinfection Technologies

Various disinfection technologies are available. Some of the more common chemical disinfectants include gaseous chlorine, calcium or sodium hypochlorite, chlorine dioxide, peracetic acid, and ozone. Physical technologies include ultraviolet radiation (UV), electron beam irradiation, and ultrasound. Other factors that have to be considered for the selection of the disinfectant are toxic effects, safety precautions, storage, ease of operation and maintenance, and regulations governing residuals standard.

1.2.1 Chlorine gas

Chlorine gas is very effective chemical and relatively inexpensive; however, it is extremely toxic and due to safety concerns it is not recommended to be used in urban areas. Chlorine gas will not be considered further.

1.2.2 Chlorine Dioxide

The use of chlorine dioxide in wastewater disinfection has been very limited in US. It therefore needs to be generated on-site. It can be produced on-site but is extremely unstable and explosive and any means of transport is potentially hazardous. The overall system is complex to operate and maintain compared with conventional chlorination. Chlorine dioxide can produce potentially toxic byproducts such as chlorite and chlorate. Chlorine dioxide will not be considered further.

1.2.3 Peracetic Acid (PAA)

Peracetic Acid is a strong oxidizer used in the food industry as a fruit and vegetable disinfectant since early 1950s. It has been used in Europe for wastewater disinfection and has been drawing more attention in recent years in the United States. It deactivates pathogenic microorganisms, viruses, and spores. The advantages on the use of peracetic acid are the ease of implementing treatment; it has a similar operation and concentration times as sodium hypochlorite and longer shelf life (12 to 18 months); absence of carcinogenic or mutagenic residuals or by-products, no quenching requirement, small dependence on pH and temperature. The disadvantages are associated with the lack of information about toxicity to aquatic environments. Manufacturers suggest that PAA is less toxic in the environment than chlorine; however more studies are required to support this statement. The use of peracetic acid has also a high cost due to limited production capacity worldwide. If a disinfection alternative is selected, PAA could be considered for further evaluation. However, it will not be used as the basis for this alternative evaluation.

1.2.4 Ozone

Ozone is a strong oxidizer that must be applied to wastewater as a gas. Its application to CSO treatment facilities is relatively new in the United States. Ozone is produced on site and generation equipment is expensive. Ozonation is a power intensive system therefore the costs of operation can also be high.

Ozone is generated depending on the demand therefore, is not currently considered practical for intermittent use in situations where the system would be frequently turned on and off or where there are wide fluctuations in flow rate and disinfection demand, such as in CSO treatment applications. Thus, ozone will not be considered further.

1.2.5 UV Radiation

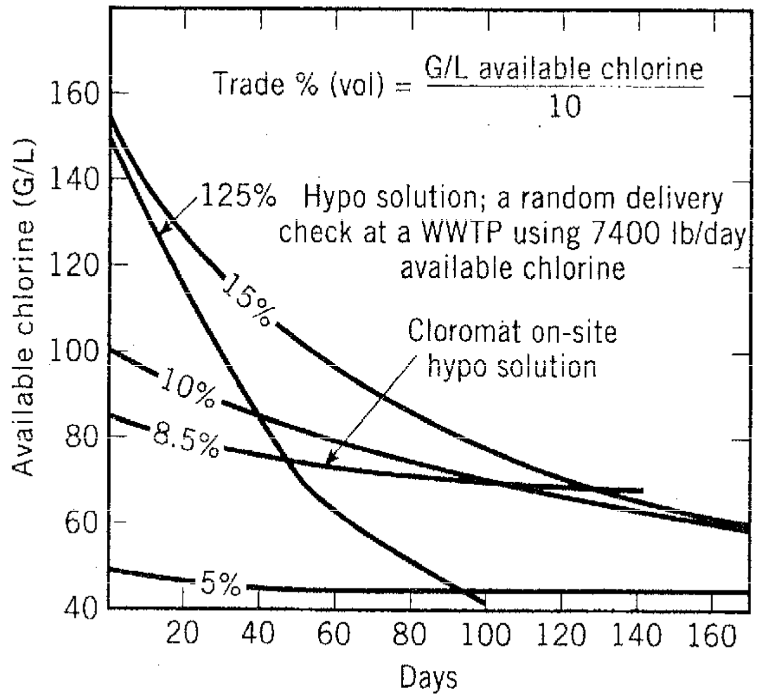
UV radiation is a type of electromagnetic radiation used for disinfection. A UV system transfers electromagnetic energy through the cell wall of an organism altering its genetic material. This destroys the ability of the cell to reproduce. UV disinfection uses the spectrum of light between 40 nm and 400 nm. The optimal wavelength for the inactivation of microorganisms is between 250 to 270 nm. UV equipment consists of the following key components: UV lamps, reactor, ballasts, lamp sleeves, UV sensors, and cleaning systems. In addition, UV equipment may include additional monitors such as on-line UVT monitors, temperature sensors and water level probes.

UV disinfection used on CSOs does not produce hazardous chemicals. The UV disinfection efficiency is highly impacted by the transmittance and suspended solids concentration of the water to be treated. UV radiation can have limited ability to treat CSO flow due to high suspended solids. CSO waters also contain material that can foul lamps and increase maintenance costs. A CSO facility using UV disinfection must be designed to handle peak flows requiring a relatively high quantity of UV lamps and associated infrastructure. Consequently the electrical infrastructure to support a UV system is significant. UV disinfection results in higher capital and O&M costs when compared to other disinfection technologies. The applicability of UV disinfection has been expanding in past years; however, in terms of experience in the US the use of UV for CSO disinfection needs further research and will not be considered further.

1.2.6 Calcium or Sodium Hypochlorite (NaOCl)

Hypochlorite is a commonly used disinfectant in populated metropolitan areas and has been applied with success as a CSO disinfectant. It is more expensive but safer to handle than chlorine gas. It can be produced on site or can be delivered in tanker trunks with concentrations between 3 to 15% of available chlorine. Hypochlorite decays over time. The decay rate can increases as a result of exposure to light, time, temperature increase or increased concentration of the compound. Figure 1-1 shows the decay rate of different sodium hypochlorite solutions. The solution can be stored for 60 to 90 days before the disinfecting ability degrades below recommended values (5% concentration). Degradation of the solution over time is a major disadvantage of sodium hypochlorite for CSO applications, due the variability of the size and frequency of rain events. Other disadvantages include the production of toxic byproducts as trihalomethanes (THMs), and the toxicity of chlorine residual to aquatic life in receiving water. THMs are chemicals that can impact public water supplies. There are no public water supplies downstream of the City's CSOs. The toxicity of chlorine residual can be addressed by adding additional chemicals that remove the chlorine before the disinfected flow is discharged. Sodium hypochlorite (NaOCl) is the most common chemical used in CSO disinfection facilities. It will be used as the basis for evaluating disinfection alternatives. Its disinfection capability has been well documented in several studies and experience in full scale facilities.

Figure 1-1
Decay Rate of Sodium Hypochlorite Solutions



Source: www.forceflow.com/hypochlorite/HypoDecayCurve.pdf

1.3 Sodium Hypochlorite Disinfection Facility Sizing

The efficiency of chlorine based disinfectants is affected by different factors like chlorine concentration, contact time, initial mixing, reactor design, temperature, pH, and wastewater characteristics. The disinfection capability depends heavily on the contact time between the chlorine and bacteria. High rate disinfection achieved through high intensity mixing and high chemical dosage can reduce required detention times. It is important to note that CSO events are extremely variable; CSO can be intermittent with short durations and relatively large flows or long duration with spikes of high flow. Bacterial and solids loads may vary greatly between and during events.

Two scenarios were studied to size the disinfection facility to meet the City's goals associated with TMDL:

- Scenario A: Capture and disinfect the CSO volume of the 5th largest storm in the typical year (1984), for CSO outfalls 002, 003 and 004. Disinfection of storms larger than the 5th largest storm (in 1984) would still occur; however, at potentially lower disinfection rates.

- Scenario B: Capture and disinfect the CSO volume to achieve 80% (002) and 99% (003 and 004) bacteria reduction for the largest storm in the 2004-2005 TMDL period.

The Scenario B sizing is in strict accordance with the assumptions and requirements of the TMDL modeling. The TMDL modeling was based on 80% control for CSO 002 and 99% control for CS0 003 and 004 during each day. Alternatively, Scenario B could be achieved on an annual basis with reduced sizing. For example CSO 002, could be sized to disinfect 100% of most of the storms, but less than 80% of the really large storm event. As noted in the *Regulatory Requirements Technical Memorandum*, the City has repeatedly raised concerns with many of the assumptions associated with the TMDL modeling. The City believes the assumptions do not represent the actual nature of CSO impacts or an understanding of how CSOs are typically controlled.

1.3.1 Design Criteria

Existing facilities in Southeast Michigan and Detroit using NaOCl have contact times between 5 through 40 minutes. The City of Detroit LTCP recommended contact times between 5 to 10 minutes for 10-year, 1-hour storm events. For short contact times higher chlorine dosages are required with high mixing intensity to achieve the required bacterial inactivation.

The Ct concept is the most important variable in CSOs conventional disinfection for determining the bacterial inactivation efficiency. The Ct is calculated as follows:

$$Ct = C \times t$$

Where:

C = Chlorine Concentration applied (mg/l)
t = Disinfection time (minutes)

The Ct concept is based on the premise that time and concentration can be traded off for similar disinfection kill. For example, 10 minutes of disinfection time at 5 mg/l provides a Ct of 50 with similar effectiveness to 5 minutes of disinfection time at 10 mg/l (also providing a Ct of 50).

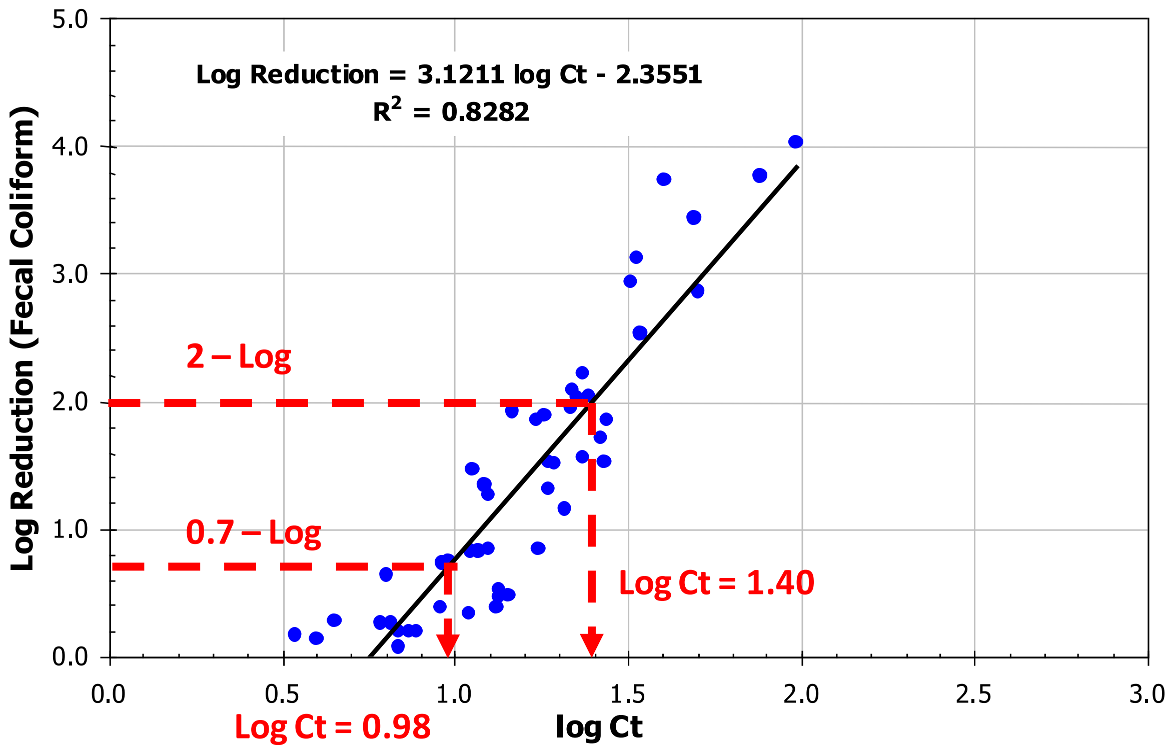
Effective mixing of the NaOCl solution and the combined sewage is essential. In practice, effective initial mixing of chlorine can be achieved through hydraulic jumps in open channels, in Venturi flumes, in pipelines, within pumps, and with static mixers or in vessels with the aid of mechanical mixing devices.

Two bench scale and two full size plant studies were considered prior to selecting the preliminary design criteria for the City of Alexandria.

1.3.1.1 Bench Scale Studies

The City of Richmond, Virginia performed a bench scale pilot tests to identify preliminary design criteria for the CSOs of the Shockoe area. The chlorine compound used was sodium hypochlorite and the Selleck-Collins disinfection kinetic model was used to study the reduction of fecal coliforms for different Ct values. Figure 1-2 shows log reduction results of the Selleck-Collins model for fecal coliforms against log Ct of sodium hypochlorite for the bench scale pilot test of the City of Richmond, VA.

Figure 1-2
City of Richmond Bench Scale Disinfection Kinetics of Sodium Hypochlorite

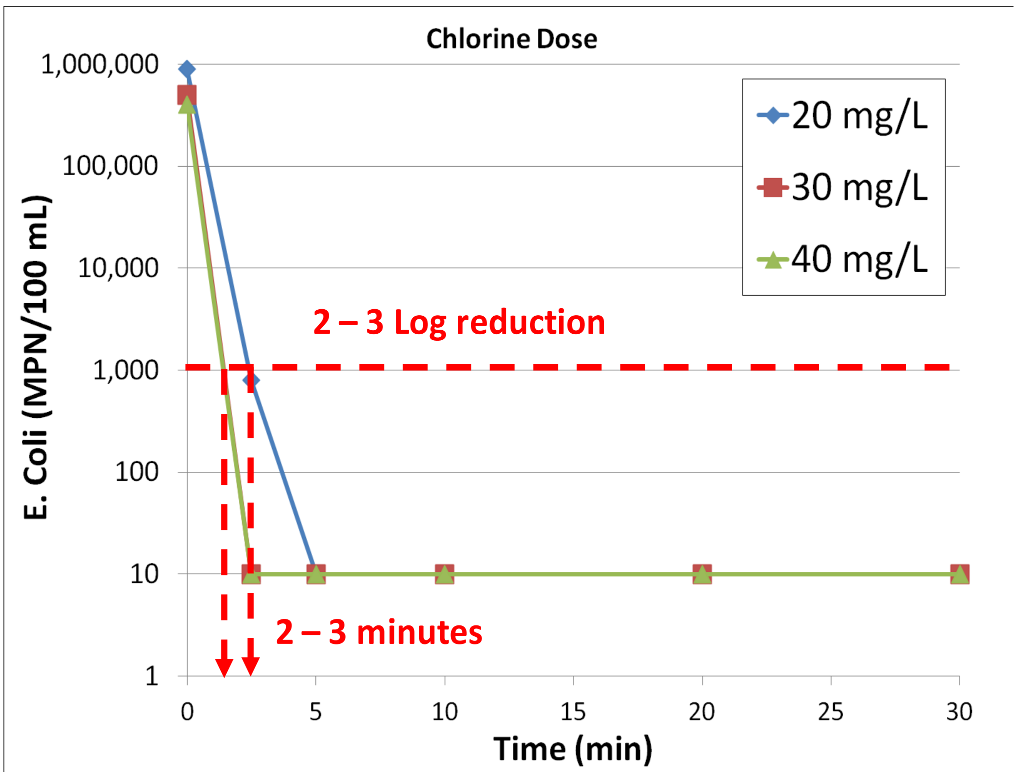


The results showed that up to 4-log reduction of fecal coliforms can be achieved with a Log Ct of 2 which represents a Ct of 100 min-mg/L. For this Ct value a chorine dose of 20 mg/L requires about 5.5 min to achieve the 4-log reduction.

Based on the bench scale figure the Ct value required to achieve 80% bacterial reduction (0.7 log) for CSO outfall 002, is 9.5 min-mg/L. The Ct value required to achieve 99% bacterial reduction, as is the required for CSO outfalls 003 and 004, is 25 min-mg/L. The CSO disinfection facilities of the Detroit Water and Sewerage Department (DWSD) use a design chlorine concentration between 10 mg/L to 38 mg/L. For a chlorine concentration of 20 mg/L, the required contact time for CSO outfall 002 is less than 1 min and for CSO outfalls 003 and 004 the required contact time is 1.2 minutes to comply with the required TMDL.

Figure 1-3 shows the results of a bench scale CSO disinfection study from the University of Iowa performed in 2009. It shows the inactivation kinetics of *E. coli* over time for three different concentrations of free chlorine.

Figure 1-3
University of Iowa CSO Bench Scale Disinfection Study

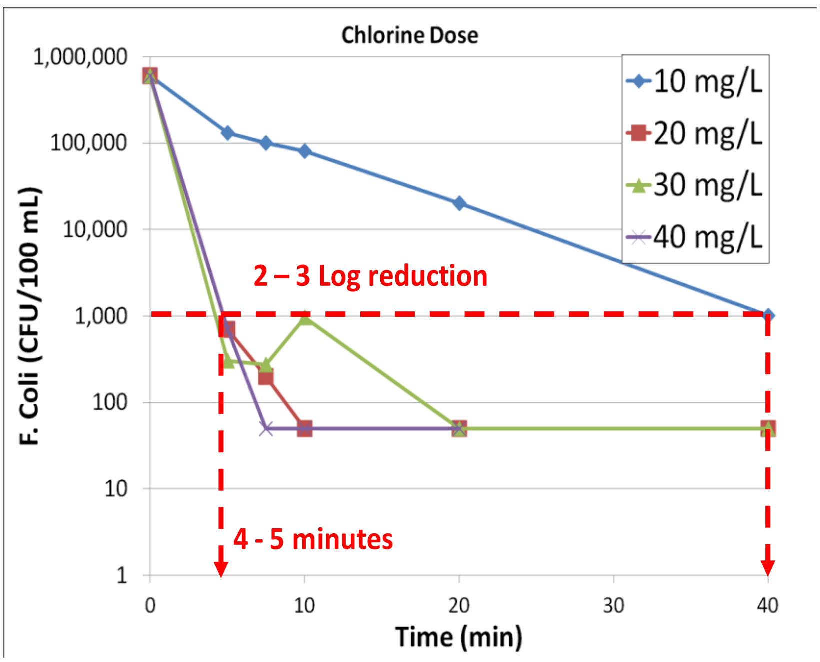


The bench scale CSO disinfection study from the University of Iowa showed that for concentrations over 20 mg/L a reduction of *E. coli* of four or more logs can be achieved in 5 minutes of contact time. Interpolation of these data indicates 3 minutes would be adequate to obtain a 2-3 log reduction. This contact is similar to the results showed on the Richmond bench scale study for a chlorine concentration of 20 mg/L.

1.3.1.2 Full Scale Studies

In the year 2000 the DWSD performed the Baby Creek CSO disinfection study to evaluate several disinfection technologies in the inactivation of fecal coliforms and *E. coli*. Figure 1-4 shows the results from Baby Creek CSO disinfection study using sodium hypochlorite for the inactivation of *E. coli*.

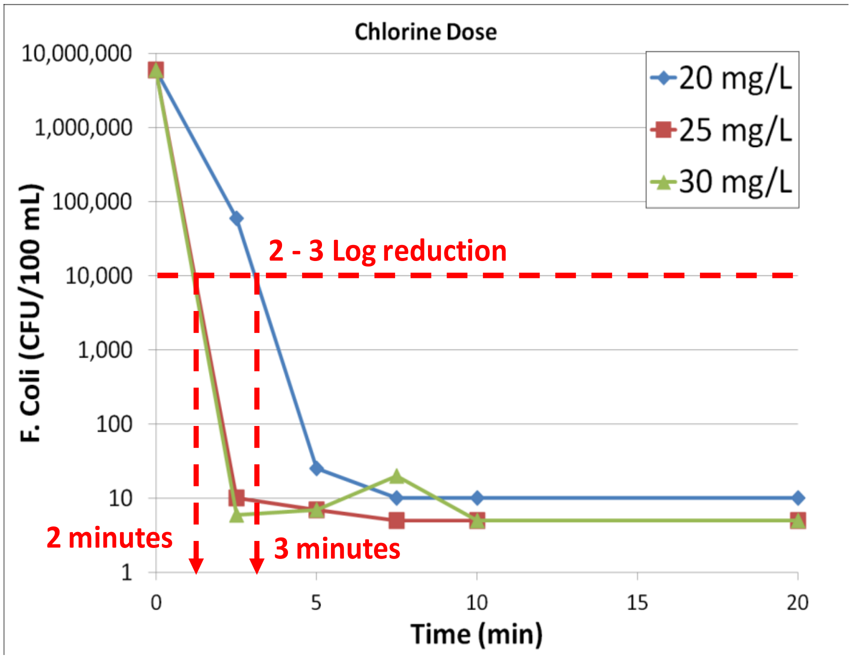
Figure 1-4
City of Detroit, Baby Creek CSO Disinfection Study



The study results showed that for a chlorine concentration of 10 mg/L a contact time of 40 minutes was required to achieve a 3 log reduction of *E. coli*. However, when the chlorine concentration was increase from 20 mg/L to 40mg/L the contact time was reduced to less than 5 min to achieve the same inactivation of *E. coli*. It appears from this study that low dose of chlorine (less than 20 mg/l) are less reliable in achieving disinfection for short contact times even with adequate Ct.

DWSD also performed a study for the Conner Creek Pilot CSO Control Facility to determine appropriate design criteria for storage, feeding and mixing of the disinfectant, and to evaluate the bacteria kill using sodium hypochlorite as a disinfectant. Figure 1-5 shows the results form Conner Baby Creek CSO Disinfection Study of year 2005.

Figure 1-5
City of Detroit, Conner Baby Creek CSO Disinfection Study



The Conner Baby Creek CSO disinfection study was performed with chlorine concentrations of 20 mg/L, 25 mg/L, and 30 mg/L. The contact times required to achieve between 2 to 3 logs of inactivation of *E. coli* were less than 3 minutes.

The results of the full scale studies are comparable with the bench scale ones for chlorine concentrations of 20 mg/L or higher. With this chlorine concentration the required contact times to achieve up to 3 logs reduction of *E. coli* ranged from 2 to 5 min. Having higher initial concentrations of chlorine improve the inactivation rate and reduce contact times.

1.3.1.3 Minimum Sizing Criteria

From a practical standpoint, a minimum detention time of 10 minutes has been selected for this preliminary disinfection alternative evaluation for sizing the disinfection tanks for the design storm, irrespective of the higher initial concentrations. The above studies demonstrate that significant treatment still occurs at increased flows and reduced detention times. In addition, a chlorine dose of 20 mg/l is used for both scenarios.

1.3.2 Sodium Hypochlorite Storage

Chlorine disinfection design dosages are typically between 10 to 25 mg/L for CSO facilities in the City of Detroit, with contact times between five to sixty minutes. The simpler chlorination arrangement consists on a flow-paced control system with a fixed chlorination feed that can be adjusted after installation (EPA, 1999).

The designed chlorination system considers an adequate capacity of on-site chemical storage according with the required dose and extra volume to allow for chemical degradation. Sodium hypochlorite can be purchased in liquid form with concentrations of 3% to 15%. A 12.5% solution may degrade to 10% in 6 to 8 weeks then the degradation rate slows (WTPC, 2006). Typically it is stored as a 5% solution of available chlorine (EPA, 1999). It should be stored at temperatures below 85 degrees Fahrenheit in a corrosion resistant tank and protected from light exposure. Typically the chemical storage is estimated to store enough chemical for 15 days of continuous treatment for the average overflow flow rate and four days of continuous treatment of the peak overflow flow rate.

For Scenario A, the minimum chemical storage is calculated to store enough chemical for 15 days of continuous treatment for the average overflow flow rate and four days of continuous treatment of the peak overflow flow rate. For Scenario B, minimum chemical storage is calculated as the chemical volume required to treat the peak storm overflow plus the chemical storage required to provide reserve storage for follow-on events so that back-to-back overflow events do not go untreated.

The design parameters for the sodium hypochlorite disinfection system and the estimated storage requirements for Scenario A are shown in Table 1-1.

Table 1-1
Design Parameters of NaOCl Disinfection for Scenario A

Disinfection Facility	Unit	D002-A	D003/4-A
Design Overflow Volume and Flowrate			
1984 5th largest storm overflow volume	MG	2.0	0.8
1984 5th largest storm flowrate	MGD	16.6	11.1
Target Disinfection			
Percentage bacterial reduction	%	99.0%	99.9%
Ct value	min-mg/L	24.9	52.0
Chlorine concentration, C	mg/L	20.0	20.0
Minimum required contact time, t	min	1.2	2.6
Sodium Hypochlorite System			
Sodium Hypochlorite Solution Strength	%	5%	5%
Sodium Hypochlorite Storage Volume	gal	4,376	1,709
Sodium Hypochlorite Storage Tank Volume	gal	4,400	2,000
Sodium Hypochlorite Storage Area	sf	83	39
Days of Storage Average Volume	days	15	18
Days of Storage Peak Volume	days	6	7

The design parameters for the sodium hypochlorite disinfection system and the estimated storage requirements for Scenario B are shown in Table 1-2.

Table 1-2
Design Parameters of NaOCl Disinfection for Scenario B

Disinfection Facility	Unit	D002-B	D003/4-B
Design Overflow Volume and Flowrate			
2005 Peak storm overflow volume	MG	31.7	17.8
2005 Peak storm flowrate	MGD	113.4	94.8
Target Disinfection			
Percentage bacterial reduction	%	80.0%	99.0%
Ct value	min-mg/L	9.5	24.9
Chlorine concentration, C	mg/L	20.0	20.0
Minimum required contact time, t	min	0.5	1.2
Sodium Hypochlorite System			
Sodium Hypochlorite Solution Strength	%	5%	5%
Sodium Hypochlorite Storage Volume	gal	11,405	9,454
Sodium Hypochlorite Storage Tank Volume	gal	16,200	6,650
Sodium Hypochlorite Storage Area	sf	334.6	81.2
Days of Storage Average Volume	days	22	15
Days of Storage Peak Volume	days	1	1

1.3.3 Dechlorination and Sodium Bisulfite Storage

Dechlorination of the disinfected effluent is required to avoid adverse impact to the aquatic life of the receiving water. Gaseous sulfur dioxide, liquid sodium bisulfite, sodium thiosulfate, sodium sulfite, and sodium metabisulfite can be used for this purpose. Sodium bisulfite is the most commonly used chemical for dechlorination due to the ease of handling, fewer safety concerns, economic reasons, and availability. For this evaluation the use of sodium bisulfite is assumed. Typical characteristics are shown in the Table 1-3 below:

Table 1-3
Sodium Bisulfite Key Properties

Property	Value
Concentration	38% (25% solutions)
Molecular Weight	104.06
Boiling Point	> 100ºC
Freezing Point	- 12ºC
Saturation Temperature	4.4ºC @ 38%
Vapor Pressure	78 mm Hg @ 37.7ºC
Specific Gravity	1.36 @ 25ºC
pH	3 to 4
Solubility in water	Completely

Sodium bisulfite can decay about 40 % over a period of six-months. The storage should consider the release of sulfur dioxide when the sodium bisulfite is stored in a warm environment; a water scrubber is typically used to diffuse and dissolve off-gas. Another operational problem is the crystallization of sodium bisulfite when the temperature drops below the saturation point: -6.7ºC for 25% solutions and 4.4ºC for 38% solutions.

The bases of design for estimating dechlorination cost are the following:

- Average total residual chlorine (TRC) of 3 mg/L in the overflow
- Dechlorination with a 25% solution of sodium bisulfite
- Dechlorination ratio: 1.7 mg/L of $NaHSO_3$ per 1.0 mg/L Cl_2 residual
- One of two storage tanks to meet storage requirements
- Temperature controlled building to house all components of the feed system
- Automatic control system with an on-line chlorine analyzer
- Mixing device for dechlorination
- Monitoring of sodium bisulfite storage every three months

The estimate size of the sodium bisulfite dechlorination storage for Scenario A is presented in Table 1-4.

Table 1-4
Sizing of Dechlorination Facilities with $NaHSO_3$ for Scenario A

Sodium Bisulfite Facility	Unit	D002-A	D003/4-A
Sodium Bisulfite for Dechlorination			
Chlorine residual	mg/L	3	3
Sodium Bisulfite Solution Strength	%	25%	25%
Sodium Bisulfite Dose	mg/L	5.1	5.1
Sodium Bisulfite Storage Volume	cf	182	71
Sodium Bisulfite Storage Tank Volume	cf	200	105
Sodium Bisulfite Storage Area	sf	5.2	7.1
Days of Storage Average Volume	days	16	22
Days of Storage Peak Volume	days	7	9

The estimated size of the sodium bisulfite dechlorination storage for Scenario B is presented in Table 1-5.

Table 1-5
Sizing of Dechlorination Facilities with $NaHSO_3$ for Scenario B

Sodium Bisulfite Facility	Unit	D002-B	D003/4-B
Sodium Bisulfite for Dechlorination			
Chlorine residual	mg/L	3	3
Sodium Bisulfite Solution Strength	%	25%	25%
Sodium Bisulfite Dose	mg/L	5.1	5.1
Sodium Bisulfite Storage Volume	gal	475	270
Sodium Bisulfite Storage Tank Volume	gal	500	300
Sodium Bisulfite Storage Area	sf	12.0	7.1
Days of Storage Average Volume	days	17	17
Days of Storage Peak Volume	days	1	1

1.3.4 Chlorination/Dechlorination Chemical Storage and Feed Building

Sodium hypochlorite and sodium bisulfite could be stored indoors in a conditioned building to minimize the degradation due to high temperature and sunlight exposure. To minimize the potential of chemical interaction the storage tanks of sodium hypochlorite and sodium bisulfite have to be isolated from each other. The estimated footprint area required for the chemical storage and feed buildings for each CSO facility for Scenario A are shown in Table 1-6.

Table 1-6
Sizing of Chemical Storage and Feed Building Areas for Scenario A

Disinfection	Unit	D002-A	D003/4-A
Sodium Hypochlorite Storage Area Required	sf	82.5	39.4
Sodium Bisulfite Storage Area Required	sf	5.2	7.1
Chemical Storage and Feed Building	sf	484.0	400.0
Footprint	ft x ft	22 x 22	20 x 20

The estimated footprint area required for the chemical storage and feed buildings for each CSO facility for Scenario B are shown in Table 1-7.

Table 1-7
Sizing of Chemical Storage and Feed Building Areas for Scenario B

Disinfection	Unit	D002-A	D003/4-B
Sodium Hypochlorite Storage Area Required	sf	338	165
Sodium Bisulfite Storage Area Required	sf	24	14
Chemical Storage and Feed Building	sf	988	616
Footprint	ft x ft	38 x 26	28 x 22

1.3.5 Chlorine Contact Tanks

The design parameters for the chlorine contact tank and its estimated size for each CSO outfall for Scenario A are presented in Table 1-8.

Table 1-8
Sizing of CSO Facilities with NaOCl Disinfection for Scenario A

	Unit	D002-A	D003/4-A
Contact Tank			
1984 5th largest storm flowrate	MGD	16.6	11.1
Chlorine Concentration, C	mg/L	20.0	20.0
Detention time, t	min	10	10
Contact Tank Volume, V	cf	15,600	10,400
Sidewater depth, d	ft	5	5
Contact Tank Area, A	sf	3,120	2,080
Number of Passes	#	6	5
Width of Each Pass	ft	8	8
Length of Each Pass	ft	65	52
Footprint	ft x ft	84 x 57	56 x 48
Peak flowrate in 1984	MGD	39.0	42.5
Detention time at peak flowrate	min	4.3	2.6
Ct at peak flowrate	min-mg/L	86.2	52.8

The design parameters for the chlorine contact tank and its estimated size for each CSO outfall for Scenario B are presented in Table 1-9.

Table 1-9
Sizing of CSO Facilities with NaOCl Disinfection for Scenario B

	Unit	D002-B	D003/4-B
Contact Tank			
2005 Peak storm overflow	MGD	113.4	94.8
Chlorine Concentration, C	mg/L	20.0	20.0
Detention time, t	min	10	10
Contact Tank Volume, V	cf	105,500	112,000
Sidewater depth d	ft	5	5
Contact Tank Area, A	sf	21,100	22,400
Number of Passes	#	10	14
Width of Each Pass	ft	10	10
Length of Each Pass	ft	211	160
Footprint	ft x ft	214 x 113	164 x 157

1.4 Location and Layout

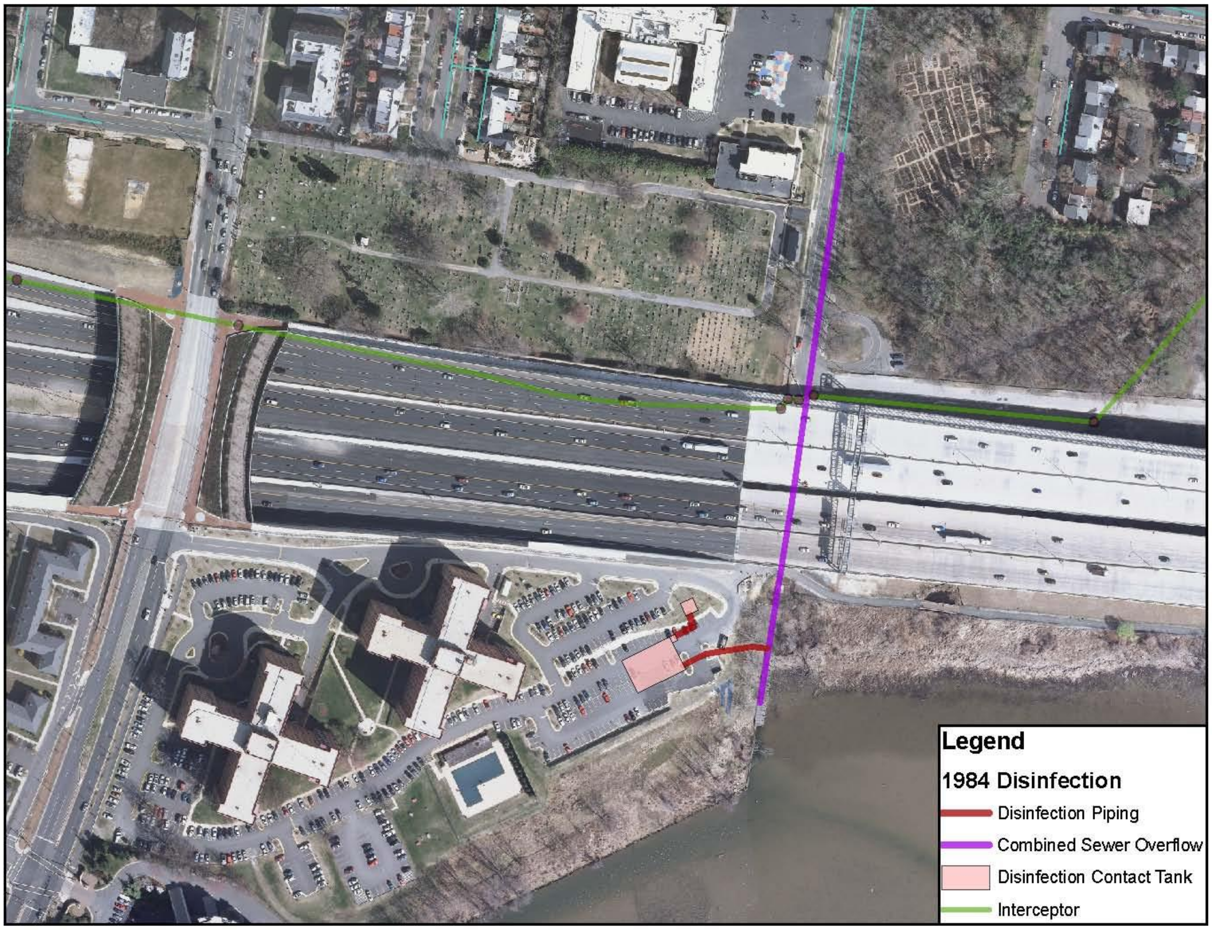
The location and projected layout of the disinfection facilities for CSO outfalls 002, 003, and 004 are shown below.

1.4.1 CSO Outfall 002

The CSO facilities could be located at the end of S. Royal Street south of the Woodrow Wilson Memorial Bridge. The CSO outfall is located west of a private condominium development. One potential location for the disinfection facility is below the existing parking lot of the condominium. Additional sites could include the parking under the bridge or at Jones Point Park (National Park Service).

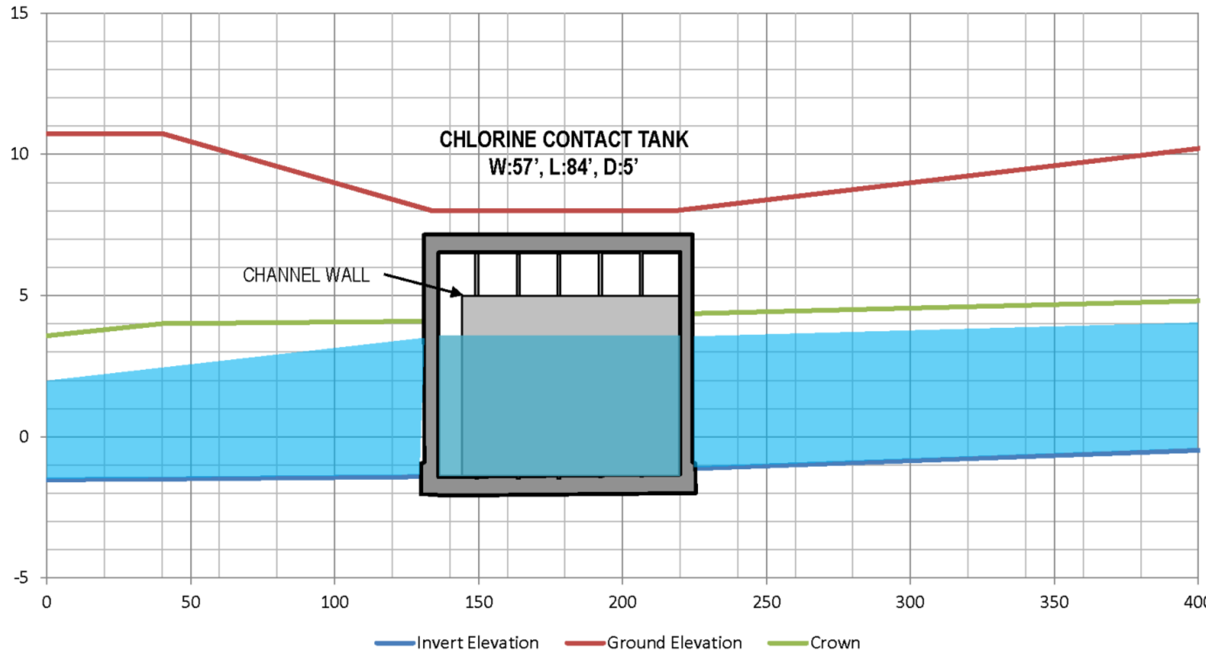
Two options of facilities have been sized depending of the scenario analyzed. The disinfection facility size for Scenario A, which treats the 5th storm of 1984 is shown in Figure 1-6.

Figure 1-6
Disinfection Facility for CSO Outfall 002 for the A Scenario (D002-A)



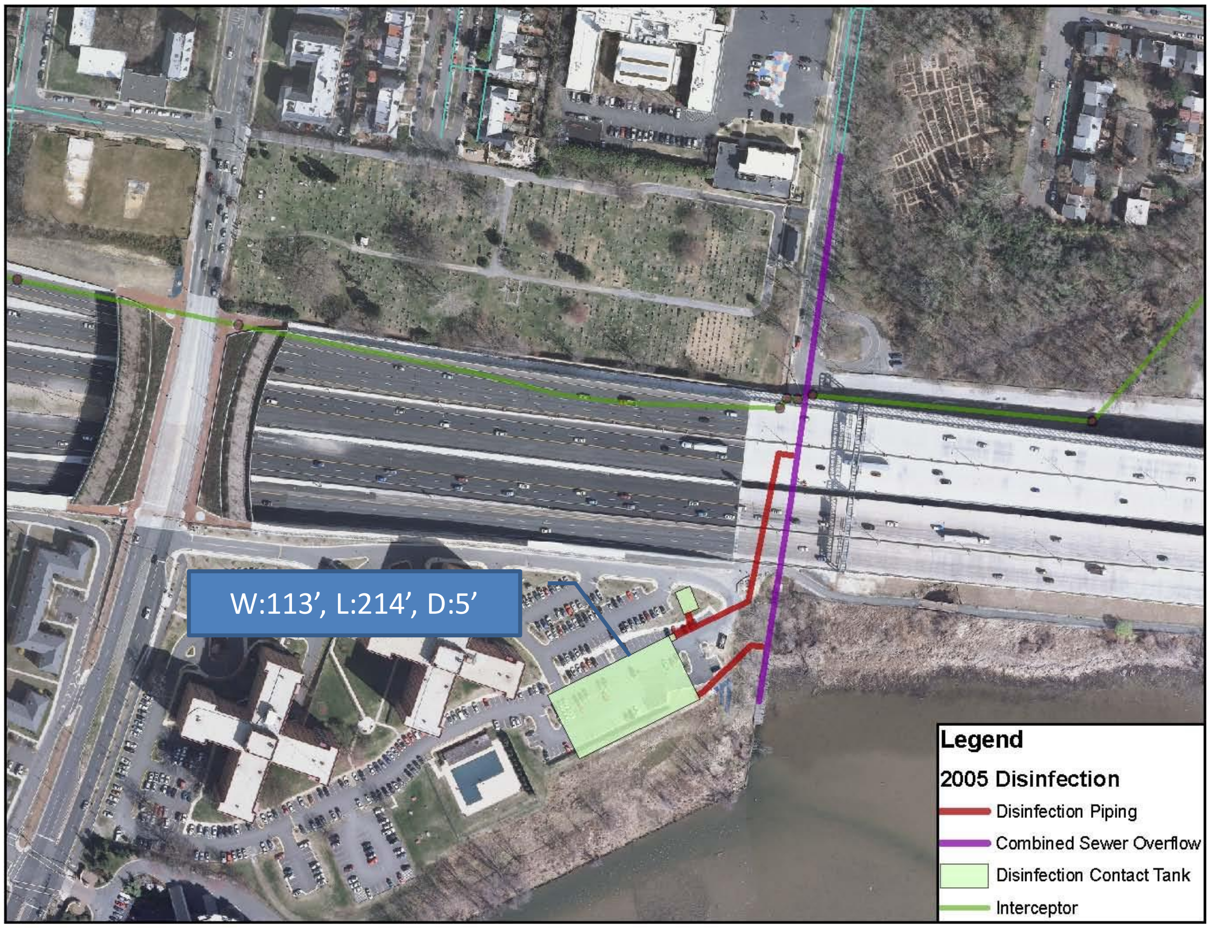
The profile of this alternative of disinfection facility is shown in Figure 1-7.

Figure 1-7
Profile of Disinfection Facility for CSO Outfall 002 for A Scenario (D002-A)



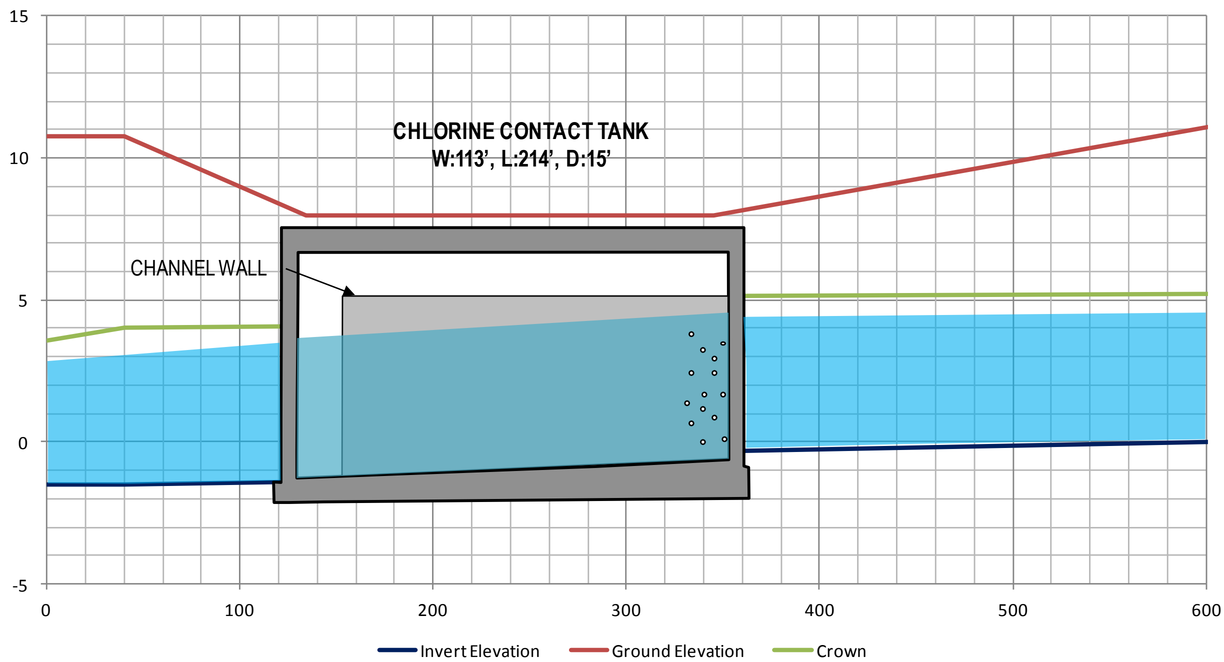
The sizing of the disinfection facility for scenario B that treats the peak storm of 2005 is considerably larger than the one in scenario A and it is shown in Figure 1-8.

Figure 1-8
Disinfection Facility for CSO Outfall 002 for the B Scenario (D002-B)



The profile of this alternative of disinfection facility is shown in Figure 1-9.

Figure 1-9
Profile Disinfection Facility for CSO Outfall 002 for the Scenario B (D002-B)



1.4.2 CSO Outfalls 003 and 004

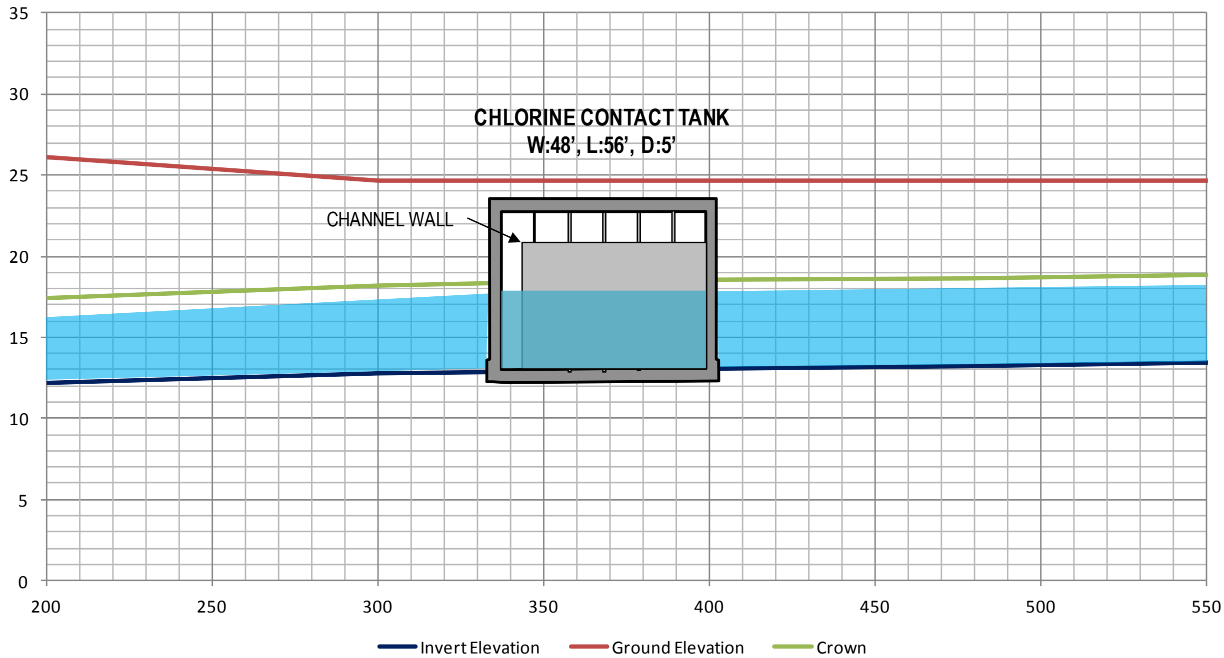
The two outfalls are located very close together; such that one disinfection facility could be sized to treat both outfalls. The area does not have many options for potential sites for the facility; a parking lot close to the CSO 003 outfall has been selected as the potential site.

The size of the facility depends on the flow to be treated. Evaluating for each of the scenarios studied the sizing of the disinfection facility for Scenario A that treats the 5th storm of 1984 is shown in Figure 1-10.

Figure 1-10
Disinfection Facility for CSO Outfall 003&004 for the A Scenario (D003/4-A)

The profile of this alternative of disinfection facility is shown in Figure 1-11.

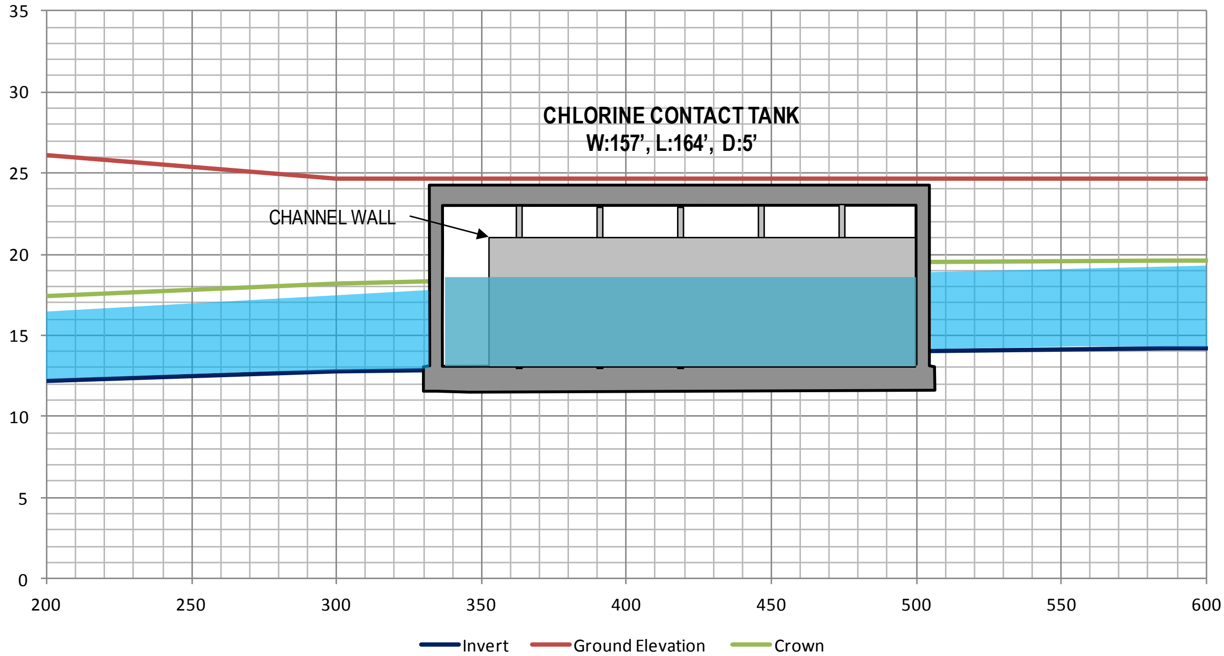
Figure 1-11
Profile Disinfection Facility for CSO Outfall 003&004 for the A Scenario (D003/4-A)



The sizing of the disinfection facility for CSO 003 and 004 outfalls for scenario B (peak storm of 2005) is considerably larger than the one in scenario A and it is shown in Figure 1-12.

Figure 1-12
Disinfection Facility for CSO Outfall 003&004 for the B Scenario (D003/4-B)

Figure 1-13
Profile Disinfection Facility for CSO Outfall 003&004 for the B Scenario (D003/4-B)



Section 2 Evaluation Criteria

The storage tanks alternatives are evaluated based criterion defined in the *Evaluation Criteria Technical Memorandum* and include:

- Cost
- CSO Reduction (CSO Volume)
- Effectiveness
- Implementation Effort
- Impact to the Community
- Expandability
- Net Environmental Benefit
- Nutrient Credits for the Chesapeake Bay TMDL
- Permitting Issues
- Required Maintenance

The *Alternatives Evaluation: Ranking and Recommendation Technical Memorandum* will rank the alternatives based on the above criteria and established weighting. The following sections are provided to illustrate how the individual CSO alternatives will rank.

2.1 Cost

Cost estimates based of the facility sizing and include chlorine contact tank, the chemical storage facility for sodium hypochlorite and sodium bisulfite, pumping system for disinfection and dechlorination, mixers, piping and storage tanks. The capital costs for two disinfection facilities, one at CSO 002 and the other one at CSO 003 for treatment of the outfalls of CSO 003 and 004 are presented in the following section. The complete cost estimate is provided in Appendix A.

There is project, independent of the LTCPU, currently under consideration by the City, AlexRenew, and Fairfax County to provide wet weather improvements that eliminate sanitary sewer overflows (SSOs) address basement backups during large wet weather events, as well other benefits for the King and West sewershed (CSOs 003 and 004). Unlike other alternatives (i.e. tunnels), these wet weather improvements cannot be addressed through disinfection alone. In order to normalize the cost of the alternatives, the estimated capital costs of these wet weather improvements are included for alternatives ST003/4 A and B.

The costs of the disinfection facilities for both scenarios analyzed are shown below.

Alternative	Construction Cost	Project Costs	Land Costs	Wet Weather Improvements	Total Capital Cost
D002-A	$8.3	$2.9	$1.7	$0.0	$12.9
D002-B	$29.8	$10.4	$4.2	$0.0	$44.4
D003/4-A	$6.1	$2.1	$2.3	$37.7[1]	$48.2
D003/4-B	$29.4	$10.3	$7.1	$37.7[1]	$84.5
[1]Select wet weather improvements, including hydraulic grade line control structure, AlexRenew WRRF upgrades and the wet weather pump station will be shared facilities with Fairfax County. The cost split for these shared facilities will be determined at a later date.					

2.2 CSO Reduction (CSO Volume)

There is only a minor CSO volume reduction associated with the disinfection alternative due to detention of CSO in the contact tanks. The volume of CSO remaining in the contact tank following a wet weather event could be pumped back into the sewer system for full treatment at the WRRF; however, no volume reduction is assumed at this time.

2.3 CSO Bacteria Load Reduction

The effectiveness is based on how well each alternative reduces the bacterial input to the receiving waters. The detention time of 10 minutes allows for operating the disinfection facilities at sufficient Ct values to achieve very high reductions in bacteria.

Alternative	Bacteria Percent Reduction	Rating
D002-A	99%	Very High
D002-B	99%	Very High
D003/4-A	99%	Very High
D003/4-B	99%	Very High

Although disinfection provides good bacteria reduction, there is no removal of other pollutants of the CSO prior to discharge.

2.4 Implementation Effort

	D002-A	D002-B	D003/4-A	D003/4-B
Are construction projects low in complexity and have commonly implemented technology?[1]	Yes	No	No	No
Is land available in the proposed project areas?[2]	Yes	No	Yes	No
Are there adequate amount of resources, labor, and expertise to complete projects?	Yes	Yes	Yes	Yes
Can the proposed project(s) be reasonably constructed in the highly urban environment of Old Town Alexandria?[3]	Yes	No	No	No
Is it likely the LTCP deadlines will be met?[4]	Yes	No	No	No
Rating	Very High	Minimal	Low	Minimal

[1] The Scenario B disinfection facilities have very large contact tanks and very large chemical storage tanks making them complex alternatives to implement effectively. The 003/4 disinfection facilities are located near outfalls 003 and 004 in a very urbanized environment with an unknown number of conflicting utilities and a complex sewer system in the vicinity.
[2] The size of the Scenario B contact tanks make it infeasible to locate near the existing outfalls in a highly urbanized environment.
[3] The Scenario B disinfection facilities are too large to construct in Old Town Alexandria. There is not a suitable location for the D003/4 disinfection facilities for either Scenario A or B.
[4] Due to the complexity of constructing disinfection facilities in the highly urbanized environment it will not be reasonable to meet the 2035 deadline.

2.5 Impact to the Community

Public acceptance is very important for CSO facilities, especially because CSOs 002, 003 and 004 are located in a highly urbanized area. The storage and delivery of chemicals in this urban area may be perceived as a negative attribute of the disinfection alternative. Additionally, the City has already received negative feedback regarding disinfection as an alternative, both from residents and environmental groups.

The design of disinfection tanks should incorporate aesthetic elements that help the facilities to blend with the surroundings creating parks, recreational areas, using covered tanks, and likely include odor control. The disinfection facilities evaluated are underground to avoid the visual impact once constructed.

There appears to be space in the area of CSO 002 to construct the disinfection tanks and associated facilities for D002-A, although it will require securing private property. Alternative D003/4-A is feasible, but impractical due the highly urbanized area around CSOs 003 and 004.

Alternative D002-B and D003/4-B are both too large and the impact on the public is too significant to reasonably consider these alternatives.

Impact on Business and Public Rating	Description	D002-A	D002-B	D003/4-A	D003/4-B
High	Improved quality of life and minimal negative impact during implementation				
Medium	Some negative impact during implementation				
Low	Excessive negative impact during implementation	X	X	X	X

2.6 Expandability

The facilities projected can be located at each outfall (CSO 002 and CSO 003). The same type of facilities can be expanded to other outfalls with the same configuration. This specific design is to be implemented for the required conditions (80% reduction in CSO 002 and 99% reduction in CSO 003 and CSO 004). If more stringent requirements need to be implemented then a new facility will be required at the outfall. Due space limitation there are only limited options to expand D002-A, and virtually no opportunities to expand the remaining alternatives.

Expandability Rating	Description	D002-A	D002-B	D003/4-A	D003/4-B
High	Multiple options and space for expansion				
Medium	Few options and space for expansion				
Low	Limited options and space for expansion				
Minimal (or none)	No opportunities for expansion	X	X	X	X

2.7 Net Environmental Benefit

The net environmental benefit is based on each alternative's Envision base score. More information about this ranking can be found in the *Evaluation Criteria Technical Memorandum*.

Net Environmental Benefit Rating	Envision Checklist Score	D002-A	D002-B	D003/4-A	D003/4-B
Very High	Base score + >35				
High	Base score + 26-35				
Medium	Base score + 16-25	X	X	X	X
Low	Base score + 6-15				
Minimal	Base score + 0-5				

2.8 Nutrient Credits for the Chesapeake Bay TMDL

There is no opportunity to generate nutrient or sediment credits for the Chesapeake Bay TMDL for the disinfection alternative.

2.9 Permitting Issues

The disinfection alterative is given a high risk for permitting issues. The construction of the contact tanks and chemical facilities is likely to be adjacent to the Hunting Creek embayment near CSO 002. One site, south of the Woodrow Wilson Bridge is considered herein; however, additional potential sites could include at the Royal Street cul-de-sac north of the bridge, in the parking lot under the bridge, or in the Jones Point Park (National Park Service). There is also a cemetery in the area. As such permits could be required from the Virginia Department of Transportation and the National Park Service, as well as general coordination. Property acquisition may also be required. It is anticipated it will be very difficult to permit chemical storage facilities in a highly urbanized and public environment.

Permitting Issues Rating	Description	D002-A	D002-B	D003/4-A	D003/4-B
High	Minimal risk of permit issues				
Medium	Moderate risk of permit issues				
Low	Significant risk of permit issues	X	X	X	X

2.10 Required Maintenance

The storage of chemicals is projected for the biggest design storm and for four average storms; in addition the chemical has a maximum time of storage of 15 days and a planned chemical delivery is expected. Extended periods of inactivity may require manual operation and disposal of stored chemicals.

Preventative and corrective maintenance will be required for the mechanical equipment, including the chemical metering pumps, mixers, and other appurtenances. The chlorine contact tanks will also need periodic maintenance to clean debris.

Requirement Maintenance Rating	Description	D002-A	D002-B	D003/4-A	D003/4-B
High	Few and infrequent maintenance				
Medium	Frequent maintenance				
Low	Frequent and expensive	X	X	X	X

2.10.1 O&M Costs

Annual operation and maintenance (O&M) costs are estimated for the disinfection alternatives and scenarios.

Alternative	Scenario	Annual O&M
D002-A	A	$0.3
D002-B	B	$1.0
D003/4-A	A	$0.2
D003/4-B	B	$0.9

2.11 Net Present Worth

The net present worth (NPW) is estimated based on a twenty (20) year period and a 3.0% discount rate. The NPW includes the project capital costs and present worth of the annual O&M.

Alternative	Scenario	Total Capital Cost	O&M NPW	NPW
D002-A	A	$12.9	$4.4	$17.3
D002-B	B	$44.4	$14.4	$58.8
D003/4-A	A	$48.2	$3.3	$51.4
D003/4-B	B	$84.5	$14.0	$98.5

2.12 Recommendation for Alternative Scoring

The locations for disinfection at CSO 003 and CSO 004 are highly confined urban areas. These areas are not practical locations for a treatment operation such as disinfection for multiple reasons. The most significant impediment is the delivery and storage of sodium hypochlorite and sodium bisulfite.

CSO 002 has more available land for the construction of a disinfection system and the delivery and storage of chemicals. However, the range of design flows and treatment capacity is an issue. In a typical year CSO 002 will require the disinfection of approximately 2 MG of overflow. The peak design storm will consume about 10% of the needed chemical for the year. While the deterioration of hypochlorite and sodium bisulfite is an issue, it can be managed as a practical matter. This requires a chemical storage facility to have approximately 15% of the total yearly demand at any given time. However, to provide a facility sized for Scenario B, chemical storage would be required for at least 3 times the total typical year needed. This would be 20 times the storage needed for the typical year. The chemicals will deteriorate during storage and have to be regularly replaced.

An additional issue is the mechanical equipment needed for the typical year design would be used regularly. The Scenario B designed facility would have equipment that is used very rarely, if ever. Experience at typical wastewater facilities indicates that if mechanical facilities are not used in regular operation, they are unlikely to function under rare events. For these reasons, disinfection for the Scenario B is not practical and is eliminated from further consideration.

It is recommended Alternative D002-A and D003/4-A be moved forward for scoring and ranking relative to the other alternatives.

The disadvantages above are further exacerbated for Alternatives D002-B and D003/4-B, as such it is recommended D002-B and D003/4-B be eliminated from further consideration.

Section 3 Opportunities for Synergy with Other Control Strategies

The disinfection alternatives are considered primary control strategies. If storage tanks or tunnels are sized and constructed for Scenario A, and four overflows per year remain for the typical year, disinfection could potentially be used to disinfect the remaining overflows by constructing facilities at AlexRenew. When disinfection is used as a complementary control strategy the facilities are very large to capture the extreme flows and the sizing and costs approach the B scenario. Additionally, since the disinfection facilities are used very infrequently, the maintenance and chemical deterioration issues are exacerbated. Additional discussion concerning the use of disinfection as a complementary control technology is provided in the *Alternatives Evaluation: Tunnels Technical Memorandum*.

Once constructed the disinfection tank alternatives lend themselves well to complementary technologies including progressive separation and green infrastructure.

On an inter-basin level, the uses of disinfection facilities do not preclude the use of other primary control strategies in other basins. For example, a disinfection facility could be installed for CSO 002, while a storage tunnel could be used for CSO 003/004.

Section 4 Additional Investigation Needs

If the distinction alternatives are retained the following additional investigations should be considered:

- Detailed site selection study;
- Geotechnical borings and study;
- CSO characterization and bench scale pilot study; and
- Alternate disinfection technologies investigation.

Section 5 References

Collins, H, Selleck R, 1972. Process kinetics of wastewater chlorination. SERL Report; No 72-5, University of California, Berkeley, November. Haas C N, 1990. Disinfection.

Attachment A

Disinfection Alternative Cost Estimates

COA LTCPU
Disinfection Summary

Date: 6-Mar-15
Prepared By: J. McGettigan
Checked By: C. Wilber

Rounding Digits	3
Period (years)	20
Present Worth Interest Rate (%)	3.0
Present Worth Factor	14.88

Alternative	Scenario	Construction Cost	Project Costs	Land Costs	Wet Weather Improvements	Total Capital Cost
D002-A	A	$8.3	$2.9	$1.7	$0.0	$12.9
D002-B	B	$29.8	$10.4	$4.2	$0.0	$44.4
D003/4-A	A	$6.1	$2.1	$2.3	$37.7	$48.2
D003/4-B	B	$29.4	$10.3	$7.1	$37.7	$84.5

Alternative	Scenario	Total Capital Cost	Annual O&M	O&M NPW	NPW
D002-A	A	$12.9	$0.3	$4.4	$17.3
D002-B	B	$44.4	$1.0	$14.4	$58.8
D003/4-A	A	$48.2	$0.2	$3.3	$51.4
D003/4-B	B	$84.5	$0.9	$14.0	$98.5

Alternative	D003/4-A
Date:	6-Mar-15
Prepared By:	J. McGettigan
Checked By:	C. Wilber

Table 1: Project Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
Contact Tank	0.09	MG	Equation	$1,062,000	Cost Curve
Contact Tank Internals (50%)				$531,000	
Building	400	SF	$500	$200,000	
Gravity Pipe (72")	150	LF	$1,715	$257,000	DC LTCP
Hypochlorite Pump System and Apprt.	2	EA	$62,000	$124,000	Lynchburg Estimate
Bilsulfite Pump System and Apprt.	2	EA	$43,000	$86,000	Lynchburg Estimate
Hypochlorite Storage Tank (2,000 gal)	1	EA	$10,000	$10,000	TRWTF 90% OPCC
Bisulfite Tank (105 gal)	1	EA	$4,700	$5,000	TRWTF 90% OPCC
Mixer, Piping and Control Valve	2	EA	$40,800	$82,000	Lynchburg Estimate
Unloading Station	1	EA	$12,800	$13,000	Lynchburg Estimate
Screening Facilities	1	LS	$750,000	$750,000	Allowance
				$3,120,000	
Electrical and Instrumentation	20%			*$624,000*	Allowance
HVAC	5%			*$156,000*	Allowance
Diversion Structure	1	EA	$600,000	$600,000	
Subtotal				*$4,500,000*	
Construction Contingency	35%			$1,575,000	
Construction Subtotal				*$6,075,000*	
Planning, Design, CM, Administration, Permitting and Easements	35%			$2,126,000	
Land Acquisition	18,000	SF	$125	$2,250,000	
Total Project				**$10,451,000**	

Table 2: Operational and Maintenance Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
Operational Cost					
Washdown Water (10% Tank Volume x 4)	36	TG	$ 4.00	$ 144	
Sodium Hypochlorite Costs	6005	lbs	$ 0.50	$ 3,002	
Dose	20	mg/L			
Volume	18	MGY			
Dispose and Refill	2				
Sodium Bisulfite Costs	766	lbs	$ 2.00	$ 1,531	
Dose	5.1	mg/L			
Volume	18	MGY			
Labor Costs	661	Hrs	$ 50.00	$ 33,050	
Daily Check (365@1.0hrs/each)	365	Hrs			
Weekly Inspections (52@4hrs/each)	104	Hrs			
Monthly Inspections (12@8hrs/each)	96				
Quarterly Cleaning (4@24hrs/each)	96	Hrs			
Maintenance Costs					
Percentage of Construction	3.00%			$ 182,250	DC LTCP Assumption
Annual O&M				$ 219,978	
Net Present Worth				$ 3,273,000	

Alternative	D003/4-B
Date:	6-Mar-15
Prepared By:	J. McGettigan
Checked By:	C. Wilber

Table 1: Project Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
Contact Tank	0.93	MG	Equation	$6,583,000	Cost Curve
Contact Tank Internals (50%)				$3,292,000	
Building	616	SF	$500	$308,000	
Gravity Pipe (72")	150	LF	$1,715	$257,000	DC LTCP
Hypochlorite Pump System and Apprt.	3	EA	$62,000	$186,000	Lynchburg Estimate
Bilsulfite Pump System and Apprt.	3	EA	$43,000	$129,000	Lynchburg Estimate
Hypochlorite Storage Tank (8,800 gal)	1	EA	$39,000	$39,000	TRWTF 90% OPCC
Bisulfite Tank (320 gal)	1	EA	$4,700	$5,000	TRWTF 90% OPCC
Mixer, Piping and Control Valve	3	EA	$40,800	$122,000	Lynchburg Estimate
Unloading Station	1	EA	$12,800	$13,000	Lynchburg Estimate
Screening Facilities	1	LS	$6,000,000	$6,000,000	Allowance
				$16,934,000	
Electrical and Instrumentation	20%			*$3,386,800*	Allowance
HVAC	5%			*$846,700*	Allowance
Diversion Structure	1	EA	$600,000	$600,000	
Subtotal				*$21,767,500*	
Construction Contingency	35%			$7,619,000	
Construction Subtotal				*$29,386,500*	
Planning, Design, CM, Administration, Permitting and Easements	35%			$10,285,000	
Land Acquisition	57,000	SF	$125	$7,125,000	
Total Project				**$46,796,500**	

Table 2: Operational and Maintenance Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
Operational Cost					
Washdown Water (10% Tank Volume x 4)	372	TG	$ 4.00	$ 1,488	
Sodium Hypochlorite Costs	31358	lbs	$ 0.50	$ 15,679	
Dose	20	mg/L			
Volume	47	MGY			
Dispose and Refill	4				
Sodium Bisulfite Costs	1999	lbs	$ 2.00	$ 3,998	
Dose	5.1	mg/L			
Volume	47	MGY			
Labor Costs	757	Hrs	$ 50.00	$ 37,850	
Daily Check (365@1.0hrs/each)	365	Hrs			
Weekly Inspections (52@4hrs/each)	104	Hrs			
Monthly Inspections (12@8hrs/each)	96				
Quarterly Cleaning (4@48hrs/each)	192	Hrs			
Maintenance Costs					
Percentage of Construction	3.00%			$ 881,595	DC LTCP Assumption
Annual O&M				$ 940,610	
Net Present Worth				$ 13,994,000	

Alternative	D002-A
Date:	6-Mar-15
Prepared By:	J. McGettigan
Checked By:	C. Wilber

Table 1: Project Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
Contact Tank	0.13	MG	Equation	$1,416,000	Cost Curve
Contact Tank Internals (50%)				$708,000	
Building	484	SF	$500	$242,000	
Gravity Pipe (72")	450	LF	$1,715	$772,000	DC LTCP
Hypochlorite Pump System and Apprt.	2	EA	$62,000	$124,000	Lynchburg Estimate
Bilsulfite Pump System and Apprt.	2	EA	$43,000	$86,000	Lynchburg Estimate
Hypochlorite Storage Tank (4,400 gal)	1	EA	$10,000	$19,500	TRWTF 90% OPCC
Bisulfite Tank (200 gal)	1	EA	$4,700	$5,000	TRWTF 90% OPCC
Mixer, Piping and Control Valve	2	EA	$40,800	$82,000	Lynchburg Estimate
Unloading Station	1	EA	$12,800	$13,000	Lynchburg Estimate
Screening Facilities	1	LS	$1,000,000	$1,000,000	Allowance
				$4,467,500	
Electrical and Instrumentation	20%			*$893,500*	Allowance
HVAC	5%			*$223,375*	Allowance
Diversion Structure	1	EA	$600,000	$600,000	
Subtotal				*$6,184,375*	
Construction Contingency	35%			$2,165,000	
Construction Subtotal				*$8,349,375*	
Planning, Design, CM, Administration, Permitting and Easements	35%			$2,922,000	
Land Acquisition	22,000	SF	$75	$1,650,000	
Total Project				**$12,921,375**	

Table 2: Operational and Maintenance Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
Operational Cost					
Washdown Water (10% Tank Volume x 4)	52	TG	$ 4.00	$ 208	
Sodium Hypochlorite Costs	14345	lbs	$ 0.50	$ 7,172	
Dose	20	mg/L			
Volume	43	MGY			
Dispose and Refill	2				
Sodium Bisulfite Costs	1829	lbs	$ 2.00	$ 3,658	
Dose	5.1	mg/L			
Volume	43	MGY			
Labor Costs	661	Hrs	$ 50.00	$ 33,050	
Daily Check (365@1.0hrs/each)	365	Hrs			
Weekly Inspections (52@4hrs/each)	104	Hrs			
Monthly Inspections (12@8hrs/each)	96				
Quarterly Cleaning (4@24hrs/each)	96	Hrs			
Maintenance Costs					
Percentage of Construction	3.00%			$ 250,481	DC LTCP Assumption
Annual O&M				$ 294,570	
Net Present Worth				$ 4,382,000	

Alternative	D002-B
Date:	6-Mar-15
Prepared By:	J. McGettigan
Checked By:	C. Wilber

Table 1: Project Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
Contact Tank	0.87	MG	Equation	$6,249,000	Cost Curve
Contact Tank Internals (50%)				$3,125,000	
Building	988	SF	$500	$494,000	
Gravity Pipe (72")	450	LF	$1,715	$772,000	DC LTCP
Hypochlorite Pump System and Apprt.	3	EA	$62,000	$186,000	Lynchburg Estimate
Bilsulfite Pump System and Apprt.	3	EA	$43,000	$129,000	Lynchburg Estimate
Hypochlorite Storage Tank (2 x 8,800 gal)	2	EA	$39,000	$78,000	TRWTF 90% OPCC
Bisulfite Tank (500 gal)	1	EA	$7,500	$8,000	TRWTF 90% OPCC
Mixer, Piping and Control Valve	3	EA	$40,800	$122,000	Lynchburg Estimate
Unloading Station	1	EA	$12,800	$13,000	Lynchburg Estimate
Screening Facilities	1	LS	$6,000,000	$6,000,000	Allowance
				$17,176,000	
Electrical and Instrumentation	20%			*$3,435,200*	Allowance
HVAC	5%			*$858,800*	Allowance
Diversion Structure	1	EA	$600,000	$600,000	
Subtotal				*$22,070,000*	
Construction Contingency	35%			$7,725,000	
Construction Subtotal				*$29,795,000*	
Planning, Design, CM, Administration, Permitting and Easements	35%			$10,428,000	
Land Acquisition	56,000	SF	$75	$4,200,000	
Total Project				**$44,423,000**	

Table 2: Operational and Maintenance Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
Operational Cost					
Washdown Water (10% Tank Volume x 4)	348	TG	$ 4.00	$ 1,392	
Sodium Hypochlorite Costs	54710.4	lbs	$ 0.50	$ 27,355	
Dose	20	mg/L			
Volume	82	MGY			
Dispose and Refill	4				
Sodium Bisulfite Costs	3488	lbs	$ 2.00	$ 6,976	
Dose	5.1	mg/L			
Volume	82	MGY			
Labor Costs	757	Hrs	$ 50.00	$ 37,850	
Daily Check (365@1.0hrs/each)	365	Hrs			
Weekly Inspections (52@4hrs/each)	104	Hrs			
Monthly Inspections (12@8hrs/each)	96				
Quarterly Cleaning (4@48hrs/each)	192	Hrs			
Maintenance Costs					
Percentage of Construction	3.00%			$ 893,850	DC LTCP Assumption
Annual O&M				$ 967,423	
Net Present Worth				$ 14,393,000	

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